

# Mathematical Statistics 4

## Course Handbook - 2007



University of Sydney  
School of Mathematics and Statistics

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## 1. Entry Requirements

Entry to Mathematical Statistics 4 is normally granted to anyone satisfying the Faculty regulations (and subject to the approval of the Head of the School), who has completed 24 credit points of Senior Statistics units with a Credit average or better.

The Faculty of Science currently requires each student enrolling as an Honours candidate in Mathematical Statistics 4 to have qualified for the Pass Degree and also to have accumulated a SCIWAM (Science Weighted Average Mark) of 60 or greater, or the equivalent at another institution.

Note:

Science students can obtain their SCIWAM's by enquiring at the Science Faculty Office after Third Year examination results have been finalised. Students are advised to check the SCIWAM calculation for themselves.

## 2. Course Administration

In 2007

- the director of statistics teaching program will be Dr Shelton Peiris, Carslaw Room 819
- the Course Coordinator for Mathematical Statistics 4 will be:  
Dr Rafal Kulik, Room 818 Carslaw Building,  
Phone 90367878. Email [rkuli@maths.usyd.edu.au](mailto:rkuli@maths.usyd.edu.au)

The Course Coordinator is the person that students should consult on all matters regarding Mathematical Statistics 4. In particular, students wishing to substitute a course from another Department, School or University must get prior written approval from the Course Coordinator. Matters of ill-health or misadventure should also be referred to the Course Coordinator.

### **3. Structure of Mathematical Statistics 4**

The program consists of seven courses worth a total of 70% and a project which counts as 30%. Only 6 courses in Statistics are given from the teaching group in 2006 year and students need to choose another course from the available Honours Level courses given within the School or by the Department of Statistics at the University of New South Wales. Details of the available courses and entry requirements can be obtained from the Mathematical Statistics 4 Coordinator or directly from the Pure Maths 4 coordinator Dr Laurentiu Paunescu (Carslaw 816, ph. 9351 2969), the Applied Maths 4 coordinator Dr Peter Buchen (Carslaw 719, ph. 9351 2965).

Students should select their additional course after consulting the Honours supervisor and the Honours Coordinator.

Each student is also required to write a project on a Mathematical Statistics topic under the supervision of a member of staff from the Statistics Research Group. This project is counted as the equivalent of three options when calculating the overall mark in Mathematical Statistics 4. Due dates for essays and projects are given on page 7.

#### 4. Current Academic Staff and their Research Interests

|                              |   |
|------------------------------|---|
| Dr Jennifer Chan             | Generalized linear mixed model, Geometric process model<br>Likelihood and Bayesian methods, Drop-out models<br>Scale mixtures distributions, Generalized-t distribution<br>Robustness, Medical and insurance applications.  |
| Dr Rafal Kulik               | Limit theorems for weakly and strongly dependent random<br>variables (empirical and quantile processes, trimmed sums,<br>extremes, U-statistics) with applications to time series<br>(linear, GARCH and LARCH processes) Queueing systems<br>and ruin theory (stochastic ordering, heavy tails) |
| Dr Shelton Peiris            | Time series analysis and applications.  |
| Dr Marc Raimondo             | Change-point models and wavelet methods.<br>Nonparametric regression and image reconstruction.<br>Inverse problems.   |
| Professor John Robinson      | Resampling methods. Asymptotic approximations.<br>Non-parametric statistics. Randomisation models.<br>Multivariate analysis. Biological modelling.  |
| Emeritus Prof. Eugene Seneta | Finite and infinite non-negative matrices and their<br>ergodicity. Probability inequalities. History<br>of probability and statistics.  |
| Dr Michael Stewart           | Asymptotic methods. Mixture models.   |
| Dr Qiyang Wang               | Limit theorems. Self-normalized sums.<br>U-statistics, Financial econometrics.  |
| Professor Neville Weber      | U-statistics. Exchangeability. Probability limit<br>theorems. Martingales. Generalized linear models.<br>Jackknife.   |
| Dr Jean Yang                 | Bioinformatics: Data analysis of microarrays,<br>Gene annotation, Sequence information and Clinical data  |

#### Retired members and their Research Interests

|                           |  |
|---------------------------|--|
| Dr. H.J. D'Abrera         | Non-parametric estimation. Robustness.   |
| Mrs. Phipps, M.           | Power functions and p-values.  |
| Emeritus Prof. Seneta, E. | Finite and infinite non-negative matrices and their<br>ergodicity. Probability inequalities. History<br>of probability and statistics. |

Recent publications of these members are available on the School's website. See the individual staff member for any reprints of their published papers.

## 5. Available Courses

The following courses will be offered in 2007.

### • Probability

This is a rigorous course on probability with a measure theoretic basis.

*Assumed knowledge:* STAT 3901 Statistical Theory; real variable analysis, preferably MATH 3909 Lebesgue Integration and Fourier Analysis courses.

*Contents:*

Axiomatic probability: probability space; continuity of probability measures; independence; product spaces; conditional probability and conditional expectations with respect to a given  $\sigma$ -field; inequalities.

Modes of convergence : almost sure convergence; convergence in probability; convergence in distribution.

Characteristic functions: properties; inversion theorem and continuity. The Helly-Bray lemma; convergence via characteristic functions.

Limit theorems: Laws of Large Numbers; Central Limit Theorem (Lindeberg); infinitely divisible distributions.

*References:*

Billingsley, P.(1995). Probability and Measure. John Wiley, New York.

Chung, K. L.(1974). A Course in Probability. Academic Press, New York.

### • Applied Probability

This is an advanced course in applied probability.

*Assumed knowledge:* STAT 3905 Markov Processes; real variable analysis.

### • Generalized Linear Models

This course covers both theory and application of generalized linear models.

*Assumed knowledge:* STAT 3902 Linear Models; STAT 3004 Design of Experiments.

*Contents:*

Review of standard normal error linear models; model checks; weighted least squares and asymptotic results.

General theory: two parameter exponential family; generalized linear model and the algorithm for maximum likelihood estimation; deviance and link functions; model fitting diagnostics.

Binary data analysis: application of general theory to logistic and binary response designs;  $2 \times 2$  contingency tables; matched case control study models.

Survival analysis; Cox regression.

Contingency tables: Hierarchical log-linear models; incomplete tables; quasi independence and quasi symmetric models.

*References:*

Cox, D. and Oaks, D. (1984). Analysis of Survival Data. Chapman and Hall, London.

Cox, D. and Snell, A. (1989). *Analysis of Binary Data*. Chapman and Hall, London.

Fienberg, S. (1980). *The Analysis of Cross-Classified Categorical Data*, MIT Press.

McCullagh, P. and Nelder, J. (1989). *Generalized Linear Models*. Chapman and Hall, London.

### • Smoothing and computational statistics

*Outline.* In this course we present an overview of modern statistical methods for curve estimation. This includes the study of kernel smoothing and orthogonal series estimators in nonparametric models (density, regression). We discuss theoretical properties such as consistency, optimality and we illustrate computational properties such as tuning by cross-validation, model selection and thresholding algorithm.

#### References.

W. Härdle, *APPLIED NONPARAMETRIC REGRESSION*, 1990.

W. Härdle, *SMOOTHING TECHNIQUES*, 1990.

B.L.S. Prakasa Rao, *NONPARAMETRIC FUNCTIONAL ESTIMATION*, 1983.

B.W. Silverman, *DENSITY ESTIMATION*, 1986.

M.P. Wand and M.C. Jones, *KERNEL SMOOTHING*, 1995.

### • Asymptotics and Inference

This is an advanced course on asymptotic techniques underlying much statistical theory.

*Assumed knowledge:* STAT 3901 Statistical Theory.

*Contents:*

Convergence of statistics; delta method; moment estimates; M-estimates including maximum likelihood (consistency, asymptotic normality, tests); efficiency of estimates; non-parametric methods; relative efficiency of tests; functional methods; robustness; bootstrap methods.

References:

Serfling, *Approximation Theorems of Mathematical Statistics*. van der Vaart, *Asymptotic Statistics* Lehmann, *Elements of Large-Sample Theory*

- **Extreme Value Theory/Risk Theory**

This course has two sections.

*Contents:*

Section 1 covers applications of extreme value theory (eg. weather, insurance and finance), extremes of iid sequences (max-stable distributions, the extremal types theorem, domains of attraction), exceedances (Poisson behaviour, generalised Pareto approximations), extremes of dependent Gaussian sequences and extremes in continuous time.

The Section 2 focuses on providing a mathematical background to compute ruin probability for an insurance company. The theory will include classical and well-established material, as well as recent developments (the case of large claims). Theoretical results will be accompanied by simulation studies. Some topics are Elements of renewal theory, Compound distributions, Insurance ruin problem, Cramer-Lundberg approximation, Ruin probability and large claims.

## 6. The Project

Each student is expected to have made a choice of a project and supervisor by the beginning of the first semester (or beginning of the second semester for students starting in July), and to commence work on their project immediately. The supervisor must be a member of staff of the Statistics Research Group. Students should consult their appointed supervisor regularly, in both the researching and writing of the work.

Three copies of the final project, typed and bound, must be handed to the Course Coordinator by

**Wednesday, 13 June 2007 (for mid-year completion).**

**Wednesday, 31 October 2007 (for end-year completion).**

The project will be assessed by three members of staff (including the supervisor). The overall final mark for the project will be a weighted mean of all three grades awarded. A weighting of 50% will be attached to the supervisor's original grade, while weightings of 25% will be attached to each of the two grades awarded by the other examiners.

A list of suggested project topics is available on request from the Course Coordinator. However, students are free to choose another topic subject to the availability of a supervisor and the approval of the Course Coordinator.

### **GENERAL INFORMATION ON PROJECTS**

1. Students should choose a topic and a supervisor by January (after consulting Head of Statistics Program / 4th year Coordinator) and should consult their supervisor weekly during the year. A typed report of about 60 pages will be examined by 3 examiners and counts for 30% of the year's assessment.
2. Guidelines to students:
  - (a) Have you taken courses closely related to the area of your project?
  - (b) Read/study for an adequate coverage of the topic. Consult key sources with the help of your supervisor.
  - (c) Integrate the sources in (b) well with your knowledge.
  - (d) Original theoretical research is not expected, but is encouraged.

3. First draft (can be hand written) to supervisor by end of August (end of March for students completing in semester 1). Final submission dates are given above.
4. Each student will give a 30 minute seminar in October (or May) on their project.
5. Guidelines for the final version:  
Check the following steps before you submit 3 copies to your supervisor.
  - (a) Is there an adequate introduction?
  - (b) Have the chapters been linked so that there is overall continuity?
  - (c) Is the account self-contained?
  - (d) Are the results clearly formulated?
  - (e) Are the proofs correct? Are the proofs complete?
  - (f) Have you cited all the references?
6. Examiners: Supervisor, plus 2 additional, chosen by 4th year Coordinator/Head of Statistics Program in consultation with supervisor. Supervisor's assessment to have double the weight of each of the other examiners.
7. Examination of the Project:
  - I. CRITERIA for each of which marks are to be awarded by each examiner:
    - (a) quality of synthesis of material in view of difficulty and scope of topic, and originality, if any.
    - (b) evidence of understanding.
    - (c) clarity, style and presentation.
    - (d) mathematical and/or modelling expertise and/or computing skills.
    - (e) presentation of seminar.
  - II. GUIDELINES to help formulate the assessment:
    - (a) Check whether points under 5 above are clearly satisfied.  
In addition the following points should be addressed by the supervisor:
      - (b) Has the student shown initiative, enterprise and hard work which are not superficially evident from the written report?
      - (c) Has the student coped well with a topic which is too broad or not clearly defined?

## 7. Assessment Procedures

Students are required to attend a minimum of 7 courses during the academic year. Only the best 7 results will be included in the overall assessment. These 7 results are weighted equally.

Student performance in each Mathematical Statistics 4 course is assessed by a combination of assignments and examinations. The assignment component is determined by the lecturer of each course and the examination component makes up the balance to 100%. The lecturer converts the resulting raw mark to a mark on the Faculty scale, which indicates the level of Honours merited by performance in that course alone.

| GRADE OF HONOURS                  | FACULTY-SCALE |
|-----------------------------------|---------------|
| First Class, with Medal           | 95–100        |
| First Class (possibly with Medal) | 90–94         |
| First Class                       | 80–89         |
| Second Class, First Division      | 75–79         |
| Second Class, Second Division     | 70–74         |
| Third Class                       | 65–69         |
| Fail                              | 00–64         |

The examiners' recommendation to Faculty of the award of Honours is based on the average mark achieved by each student, over the 7 best courses and the Project. Courses account for 70% of the assessment and the Project for the remaining 30%. (The assessment procedure for the project is outlined on pages 8 and 9.)

**Note:** All assessable student work (such as assignments and projects) should be completed and submitted by the advertised date. If this is not possible, approval for an extension should be sought *in advance* from the lecturer concerned or (in the case of Honours projects) from the Course Coordinator. Unless there are compelling circumstances, and approval for an extension has been obtained in advance, late submissions will attract penalties as determined by the Board of Examiners (taking into account any applications for special consideration).

Appeals against the assessment of any component of the course, or against the class of Honours awarded, should be directed to the Head of School.

Students are advised to read the pamphlet entitled "*Guide to Essay Writing for Science Students*" available from the Science Faculty Office. In addition, students should follow as closely as possible the guidelines presented on page 8.

**Note:**

Students who have worked on their projects as Vacation Scholars are required to make a declaration to that effect in the Preface of their theses.

## 8. Seminars

Mathematical Statistics seminars are usually held fortnightly on Friday afternoons. These seminars are an important forum for communicating ideas, developing critical skills and interacting with your peers and senior colleagues. Seminars are usually given by staff members and invited speakers. All full-time research students and all Mathematical Statistics 4 students are expected to attend these seminars.

Each Honours student must give a seminar in their final semester. Mathematical Statistics 4 students deliver a half-hour seminar on their project. Students can obtain advice on seminar presentation from their supervisor. Students are expected to give the title and abstract of their talks to the seminar organizer (Dr Marc Raimondo) *at least* two weeks in advance.

## 9. Entitlements

Mathematical Statistics 4 students enjoy a number of privileges, which should be regarded as a tradition rather than an absolute right. These include:

- Office space and a desk in the Carslaw building.
- A computer account with access to e-mail and the World-Wide Web, as well as T<sub>E</sub>X and laser printing facilities for the preparation of projects.
- A photocopying account paid by the School for assembling project source material.
- After-hours access key to the Carslaw building. (A deposit is payable.)
- A pigeon-hole in room 728 – please inspect it regularly as lecturers often use it to hand out relevant material.
- Participation in the School's social events.
- Class representative at School meetings.

## 10. Scholarships, Prizes and Awards

The following prizes may be awarded to Mathematical Statistics 4 students of sufficient merit. Students do not need to apply for these prizes, which are awarded automatically.

### **George Allen Scholarship** Value: **\$400**

This is awarded to a student proceeding to honours in Mathematical Statistics who has shown proficiency in all Senior units of study in Mathematical Statistics.

### **University Medal**

Awarded to Honours students who perform outstandingly. The award is subject to Faculty rules, which require a mark of at least 90 in Mathematical Statistics 4 and a SCIWAM of 80 or higher. More than one medal may be awarded in any year.

### **Ashby Prize** Value: **\$250**

Offered annually for the best essay, submitted by a student in the Faculty of Science, that forms part of the requirements of Pure Mathematics 4, Applied Mathematics 4 or Mathematical Statistics 4.

### **Barker Prize** Value: **\$375**

Awarded at the fourth (Honours) year examination for proficiency in Pure Mathematics, Applied Mathematics or Mathematical Statistics.

### **Norbert Quirk Prize No IV** Value: **\$130**

Awarded annually for the best essay on a given mathematical subject by a student enrolled in a fourth year course in mathematics (Pure Mathematics, Applied Mathematics or Mathematical Statistics) provided that the essay is of sufficient merit.

### **Australian Federation of University Women (NSW) Prize in Mathematics** Value: **\$100**

Awarded annually, on the recommendation of the Head of the School of Mathematics and Statistics, to the most distinguished woman candidate for the degree of BA or BSc who graduates with first class Honours in Applied Mathematics, Pure Mathematics or Mathematical Statistics.

## **11. Life after Fourth Year**

Students seeking assistance with post-grad opportunities and job applications should feel free to ask lecturers most familiar with their work for advice and written references. The Head of Statistics Programme, the Course Coordinator and the course lecturers may also provide advice and personal references for interested students.

Students thinking of enrolling for a higher degree (MSc or PhD) should see the Director of Postgraduate Studies Dr David Easdown (or Professor N. Weber) for information. Students are also strongly encouraged to discuss potential research topics with individual staff members.

Students who do well in Mathematical Statistics 4 may be eligible for postgraduate scholarships, which provide financial support during subsequent study for higher degrees.